

NOTES ON THE LIFE-HISTORY OF *LIMNOPHORA NIGRIORBITALIS* MALL.
(DIPTERA, ANTHOMYIIDAE.)

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(Seven Text-figures.)

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This fly was identified for me by Mr. J. R. Malloch, who described the female in 1924. The type, a single female, was collected by the late Dr. E. W. Ferguson in 1923, and it is now at the School of Public Health and Tropical Medicine in Sydney, where Mr. F. H. Taylor allowed me to examine it.

A description of the male, not previously recorded, is given below, together with a more detailed description of the female than that given by Malloch.

Description of the Adult.

♂, ♀. Frons about one-third of head-width, sides almost parallel, in profile sloping straight back, making with the face an angle greater than a right angle. Fronto-orbital bristles: anterior pair on each side well developed and curved inward, almost meeting in the centre line; posterior pair on each side smaller and curved slightly outward and backward. Two pairs of well-developed vertical bristles. Antennae with lower apical angle rounded, upper one squared; arista pubescent, but not densely so, about equally haired above and below. Face silvery, concave, without carina, and devoid of bristles between the bases of antennae and vibrissae. Proboscis thick, with fleshy labellae; palpi clubbed slightly. Mesonotum brown with three darker brown stripes not distinctly marked; pleura and margins of mesonotum lavender-grey; some brown markings on upper part of pleura; scutellum brown. Dorsocentrals 2 + 3. Pteropleura bare, hypopleura bare. Sternopleurals 3, not forming an equilateral triangle, and unequally developed, the postero-dorsal one very long and strong. Prosternum with fine setulae on side margins; basal abdominal sternite with fine hairs. Fore tarsus widened, fore tibia without median bristle. Wings clear, third wing-vein with minute setulae at base on upper and lower surfaces. Calyptrae white; halteres yellow. Length $3\frac{1}{2}$ to 4 mm.

♂. Frons velvety-black except for a narrow central triangle, with base at ocelli and apex towards antennae, which is dull black. Cheeks do not project in front of eyes, so are not normally visible in profile. Abdomen: dorsal surface (Text-fig. 1), first tergite dark brown with a small spot of grey showing on the outer edge on each side; second and third tergites with a central fore and aft strip of dark brown and a velvety-black patch on each side of it, leaving a triangular piece of silvery-grey on the anterior margin of each side, the apex of the grey triangle pointing inward; fourth tergite with a central triangular patch of dark brown, grey on each side. Ventral surface lavender-grey. Legs black, except the fore tarsi and apical segment of middle and hind tarsi, which are

yellow with black bristles; and the ventral surfaces of the femora, which are greyish. Apical spurs on fore and middle tibia well developed, smaller on hind tibia; one weak median dorsal bristle on hind tibia.

♀. Frons, viewed from above, velvety-black on sides, dull black in centre; viewed from front or side the centre part is dark bronze. Cheeks project in front of eyes, so they are visible in profile. The dorsal surface of the abdomen is brown, with grey markings as in the male, except that the grey triangles on the second and third segments are much smaller and may hardly show at all; the ventral surface is lavender-grey with brown on the outer edges of the first three segments. Legs: tarsi black, tibiae dark brown; dorsal surface of femora brown, ventral surface greyish. Apical spurs well developed on middle tibia, weaker on fore and hind tibiae; one median postero-dorsal bristle on middle tibia, and one median dorsal bristle on hind tibia.

No adults have been taken when net collecting.

Classification.

In Malloch's key to the Sub-families of the Australian Muscidae (1925), the fly runs down to the Phaoniinae, except that it does not agree exactly with couplet three, for the two upper pairs of orbital bristles are directed slightly outward. In his key to the Phaoniinae (1925), the fly runs down to the genus *Limnophora*; and in his key to the species (1925a), it runs down to *nigriorbitalis*, except that couplet four, which reads "Entire frons including orbits opaque deep black", would be more accurate with the addition of the words "when viewed from above", as when viewed from the front or side the centre appears bronze in the female.

In Curran's key to the Muscidae (1934) the fly runs down to the couplet containing *Limnophora* and *Pseudolimnophora*; it passes the former and goes on to the genus *Pseudolimnophora*.

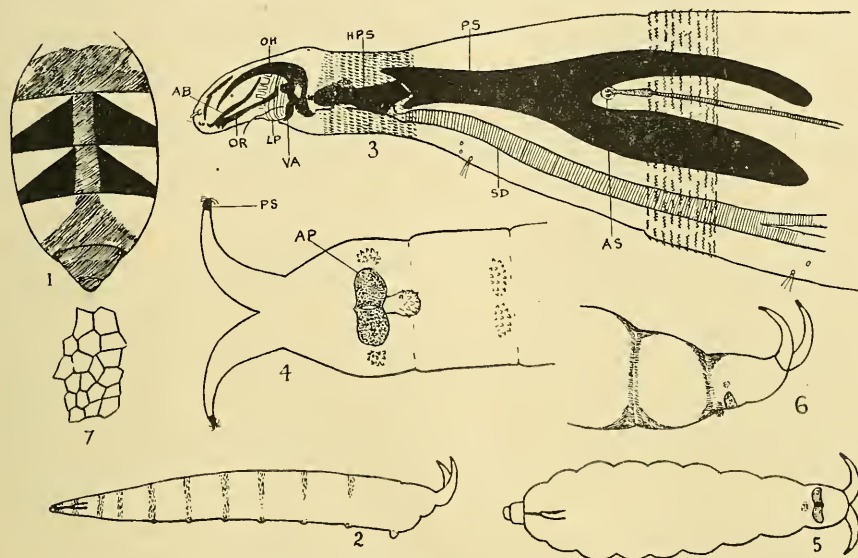
In Collin's key to the British Limnophora (1921) it runs down to the sub-genus *Pseudolimnophora*, with one exception: the frons in profile is straight and sloping; the keys says, "Frons in profile convex and sloping".

The Larva (Text-figs. 2, 3, 4).

When alive the larva is creamy-white; the skin is transparent; the internal organs can be seen, and the tracheal tubes can be traced from the anterior to the posterior spiracles; the jaws can be seen even if retracted. When killed, the skin becomes opaque. The shape is cylindrical, it tapers gradually in front to the very small head; the posterior segment narrows rather abruptly, then divides into two divergent horns with black tips. Larvae grow to 8 mm. in length, and to 1 mm. in width.

There are three thoracic and eight abdominal segments. The anterior portion of the first thoracic segment (Text-fig. 3) is covered with rows of tiny hooks with points directed backward; this portion is drawn inward when the head is retracted; the posterior portion of this segment bears the anterior spiracles. The second and third segments each have, on their anterior border, about ten rows of backwardly-directed hooks; the hooks do not form continuous rows, but are arranged in little groups. The ventral surface of the first segment bears at least two pairs of sensory organs, each in the form of a circular disc; the second and third segments each have at least one pair of similar organs. Each of the three segments bears also another pair of sensory organs on the ventral surface, in the form of a tuft of three hairs. Similar organs are described by Keilin (1917) for *Melanochelia riparia* Rond.

On the anterior borders of the first seven segments of the abdomen are broken rows of small backwardly-directed hooks; there are approximately eight rows on the first segment, and they are reduced gradually to five rows on the dorsal part of the seventh. The rows of hooks extend all round on the first three segments, but are more and more restricted to the dorsal surface on succeeding segments (Text-fig. 2). On the anterior border of the ventral surface of segments two to seven there is a pair of papillae bearing larger hooks; the first papillae



Text-figs. 1-7.—1. Abdomen of male, dorsal surface, $\times 24$ (approx.).—2. Larva, side view, $\times 7$.—3. Anterior end of larva, $\times 100$; *ab*, anterior spiracle; *hps*, hypopharyngeal sclerite; *lp*, labial palp; *oh*, oral hook; *or*, oral rod; *ps*, pharyngeal sclerite; *sd*, salivary duct; *va*, ventral arch.—4. Posterior end of larva, $\times 20$; *ap*, anal plate; *ps*, posterior spiracle.—5. Pupa, ventral surface, $\times 8$ (approx.).—6. Posterior end of pupa, side view, $\times 14$ (approx.).—7. Network pattern on surface of pupa, $\times 48$.

are very small, succeeding pairs are larger. These pads are used in locomotion. On the ventral surface of the eighth segment (Text-fig. 4), at the anterior edge, is a rounded flexible process bearing hooks; behind this is the anal plate, on each side of which is a small prominence bearing hooks. Posteriorly the segment divides into two horns, the tips of which are chitinized and bear the spiracles.

The head (Text-fig. 3) is very small and can be completely retracted. It bears paired antennae, maxillary palps, sensory organs and large labial palps.

The buccopharyngeal armature consists of three main parts, heavily chitinized. The posterior portion is the basal piece or pharyngeal sclerite, consisting of an anterior, elongated, central portion, and posteriorly of paired dorsal and ventral prolongations or horns; the dorsal horns are separate, but the ventral ones, though lying as far apart as the dorsal pair, are connected by thin chitin, extending from their ventral edges and joining in the median line. Anteriorly, this piece articulates with the hypopharyngeal sclerite, which consists of elongated side-pieces, connected by thin chitin for part of their length; below it are slender

rods, and from the posterior end the large salivary duct is given off. Anteriorly this piece articulates with the posterior prolongations of the paired oral hooks. The oral hooks are long and narrow; they are joined by the median ventral arch. Connected also with the hooks, and moving in conjunction with them, are the oral rods and anterior bands.

The larvae are carnivorous; they kill small worms and larvae; when kept in tubes together they do not readily kill one another, but will do so eventually. The large size of the salivary duct, the large labial palps, and the presence of the median ventral arch are all, according to de Vos-de Wilde (1935), characteristic features of carnivorous larvae.

The larvae are amphineustic when full grown. Very young larvae have not been found, so it has not been ascertained if they are amphineustic in all stages; but immature larvae have been examined, in which the posterior spiracles and the buccopharyngeal armature were not fully chitinized, but anterior spiracles were present.

The Pupa (Text-figs. 5, 6, 7).

The pupa is cylindrical in shape; it narrows abruptly anteriorly to a beak-like projection formed by the first and second thoracic segments, and it tapers gradually to the last segment, which divides into two horns, as in the larva. Pupae vary in length from 4 mm. to 6 mm., and in breadth from 1 mm. to 1.5 mm. They are brown in colour, and the surface is marked with a network pattern (Text-fig. 7) of dark brown lines on a lighter brown background. On each side of the beak, and extending on to the next segment, is a raised fold; this is the line on which the pupa splits for the emergence of the fly. On the ventral surface of the second to the seventh abdominal segments there are hooks among the network lines; these are the hooks of the larval papillae. On the eighth segment the central process persists as a small prominence bearing hooks. Behind this is the anal plate, red-brown in colour, not covered by the surface network, and with a dark-brown centre. On each side of the anal plate are hooks in the network.

Clean wet pupae are transparent; the larval jaws can be seen; and, as development proceeds, the shape of the imago can be seen, the dark legs becoming more and more distinct. The imago lies in the anterior portion of the pupa, leaving the two posterior segments empty. Pupae found in earthy moss are sometimes very dark and dirty, and are not then transparent.

Occurrence.

Larvae and pupae have been collected in various streams in the Yass district between September and May, over several years. They are to be found in moss or water-weeds, in running water, or at the edges of streams. In some instances they were in moss some inches above water; and once they were several inches below water; the river had risen and the water had been well over the moss for ten days.

They may be found in well-grown cushions of moss by parting the leafy growth; they are not seen on top of the moss. But the most satisfactory method is to collect the moss, wash it in a strainer with a fairly fine mesh, and then examine. This method is very necessary when the moss is stunted, as the larvae are then amongst the roots. When climatic conditions had caused the moss to die off, or become very scarce, larvae were found in water-weeds and the matted root-growth of willows.

They are found singly, and are most numerous in well-grown moss cushions, where one might find half a dozen in a few moments; but usually about 8 or 10 larvae and pupae in an hour's search would be a good catch.

Larvae have been found in each month from September to May; except January, when no collecting was done, and March, when very little was done. Pupae were found in each month from September to May, except January. Adults emerged in each month from October to May, except March.

More than fifty larvae were collected, mostly full grown or nearly so. Only three immature larvae were found; they were 3 mm. and 3.5 mm. in length, and were found in October, the month in which most collecting was done.

The larvae were kept in corked tubes with wet moss, but no serious effort was made to give them suitable conditions, and usually they pupated soon after capture, or died. In one case two larvae, collected in May, were put into a tube; one pupated in August, having eaten the other in the interval.

The length of the pupal period was not determined accurately, as most adults emerged from collected pupae; or when larvae pupated in captivity the actual date of pupation was not obtained. The most accurate records obtained showed pupal periods of about two weeks in February, and about three weeks in October and May.

Summing up, from the records obtained, it may be said that larvae can be found all the year round, pupae from August to May, and adults from September to May.

More than thirty adults were obtained; there were nearly twice as many males as females. They lived only a day or two, but that may have been due to unsuitable conditions.

The flies emerged in the mornings, usually before ten o'clock. Emergence can take place even if the pupa is dry; one fly emerged from a pupa which had been dry for nine days. Often the anterior cap does not break off when the fly emerges and the parts come together again, so it is not always obvious whether a pupa is empty or not.

Larvae and pupae are similar in many respects to the same stages of *Melanocheilia riparia* Rond., described briefly by Halliday (1857), and in detail by Keilin (1917), which are found under the same conditions in Europe.

Johannsen (1935) gives a key to the larvae and puparia of the aquatic Anthomyiidae of North America, in which this species runs down to the genus *Limnophora*. His three described species are found under conditions similar to those in which this one occurs.

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